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INFLUENCE OF CRYOTHERAPY WITH PULSE COMPRESSION ON THE FUNCTIONAL CONDITION OF THE KNEE JOINT AFTER PARTIAL MENISCECTOMY

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ABSTRACT

The aim: To study the effect of cryotherapy with adjustable pulse compression in patients after arthroscopic partial meniscectomy on the functional state of the knee joint in the early period of rehabilitation.

Materials and methods: A total of 63 patients took part in the research: the experimental group included 32 patients (23 men and 9 women), and the control group - 31 patients (21 men and 10 women). In order to determine the effect on the functional state of the knee joint after arthroscopic partial meniscectomy in the experimental group, cryotherapy with adjustable pulse compression was used with the help of «GIOCO CRYO – 2» system; ice bags were used in the control group. In the research process, the following methods were used: visual analogue point scale, sonography, goniometry and myotonometry.

Results: It was found that in the experimental group, under the influence of cryotherapy with adjustable pulse compression, there was a progressive decrease in the intensity of the pain syndrome, the accumulation of reactive synovial fluid, a dynamic increase in the amplitude of movements of the operated joint, and an improvement in the muscle tone of the quadriceps femoris ($p < 0,05-0,001$).

Conclusions: Thus, cryotherapy with adjustable pulse compression has shown a positive effect on the functional state of the knee joint in the early period of patients' rehabilitation, after partial meniscectomy and can be recommended for use in clinical practice.

KEY WORDS: meniscus, knee joint, cryotherapy with adjustable pulse compression, meniscectomy, pain syndrome, synovitis, range of motion, myotonometry

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INTRODUCTION

Among all injuries of the lower extremity, the frequency of injuries of the knee joint is up to 75% of cases [1]. In the structure of injuries of the knee joint elements menisci constitute up to 85,3% of all cases [2]. The average annual frequency of meniscal injuries is increasing and is becoming the most common surgical intervention on the knee joint [3].

The introduction of arthroscopy in clinical practice has significantly improved the results of the knee joint injuries treatment. However, surgery, even minimally invasive, causes pain syndrome, the development of reactive synovitis, weakness of the quadriceps femoris, impairment of neuromuscular coordination of movements, the elimination of which in the shortest possible time allows speeding up restoration of joint function.

It is believed that the use of cold is one of the most common means used as an effective non-pharmacological intervention for pain treatment in cases of

injuries. The following effects of cryotherapy are most often reported - pain relief, reduction of inflammatory oedema and elimination of muscle spasm [4, 5].

THE AIM

To study the effect of cryotherapy with adjustable pulse compression in patients after arthroscopic partial meniscectomy on the functional state of the knee joint in the early period of rehabilitation.

MATERIALS AND METHODS

A total of 63 patients aged 18 to 35 years were under observation. Using the method of forming a random sample, patients were divided into a control group (31 patients, 21 of which were men and 10 - women) and an experimental group (32 patients, 23 of which were men and 9 - women). The average age of patients in

the control group was $27 \pm 1,2$ years, and in the experimental one - $26 \pm 1,6$ years. Surgical interventions were performed on both the right and left knee joints. A total of 63 partial meniscectomies were performed: 51 interventions on the medial meniscus and 12 on the lateral one. The surgery was performed under conduction anaesthesia and lasted no more than 30 minutes. All patients underwent a full range of clinical examinations. In addition, radiography of the knee joint in two projections as well as ultrasound investigation and magnetic resonance imaging were necessarily performed. Typically performed surgery, as a treatment measure, provided clear controlled conditions for assessing the role of cryotherapy with adjustable pulse compression in restoring the functional state of the knee joint in the early postoperative period.

In order to determine the effectiveness of cryotherapy with adjustable pulse compression on the functional state of the knee joint of patients in the experimental group after performance of partial meniscectomy during the first hours «GIOCO CRYO - 2» system was used. «GIOCO CRYO - 2» system consists of a pump, cuffs for compressing the area of the joint and a microprocessor that controls the pump (Fig. 1).

In the control group, coating the knee joint area with bags of crushed ice was used for local cryotherapy.

The duration of the procedure was 15 minutes, three times a day, the first ten days after the intervention in the studied groups of patients.

Important indicators of effective recovery of the knee joint function after partial meniscectomy in the early postoperative period are the intensity of pain syndrome, the severity of reactive synovitis, increased range of motion in the joint and the condition of the quadriceps femoris as the main stabilizer of the knee joint.

They formed the basis of evaluating the effectiveness of cryotherapy with adjustable pulse compression on the restoration of knee joint functions.

To do this, the following studies were conducted: assessment of pain syndrome according to the point visual analogue scale; sonography of operated knee joints to determine the severity of synovitis; goniometry to determine the range of motion of the knee joint and myotonometry to assess the tone of the quadriceps femoris.

The indicated research methods were used on the first, third and tenth days after surgery. Examinations of patients of both groups were carried out during a control examination in the clinic.

STATISTICAL ANALYSIS

The results of the research were processed using the software package Statistica 6.0.

Qualitative data are represented as numbers and percentages, while continuous numerical data are represented as mean \pm standard deviation. Numerical variables were compared between study groups using Student's t-test. The obtained indicators had a normal distribution (according to the Shapiro-Wilke criterion).

RESULTS

One of the criteria for the effectiveness of knee joint function restoration in the early postoperative period is pain syndrome. For a reliable assessment of pain intensity, we used a point-based visual analogue scale (VAS) [6].

The results of the study of the pain syndrome dynamics according to the point-based visual analogue scale (VAS) of the patients in the postoperative period are presented in Table I. On the first day of using cryotherapy, the pain syndrome index in the control group was $7,49 \pm 0,18$ points, which is characterized as severe pain, and in the experimental group - $5,81 \pm 0,1$ points, which corresponds to moderate pain ($p < 0,001$).

On the third day of rehabilitation, the pain syndrome in patients of the experimental group decreased to $4,98 \pm 0,23$ points, while in the control group it decreased to only $6,11 \pm 0,25$ points, that is, it remained within the range of severe pain ($p < 0,001$).

In the subjects of the experimental group, a decrease in the intensity of the pain syndrome in the first days after the surgical intervention made it possible to reduce the use of painkillers. The same tendency was observed up to the tenth day after surgery. The level of pain syndrome in patients of the experimental group on the tenth day decreased to $1,03 \pm 0,25$ points, and in the control group - $2,70 \pm 0,21$ points ($p < 0,001$).

The exudative component of inflammation is not as sensitive to the patients as the pain syndrome, but is important as an objective indicator of the activity of reactive synovitis. The reactive inflammatory aseptic process in the joint is a necessary, protective reaction of tissues to damage [7].

However, quite often it becomes excessive, pre-determining a long and sometimes prolonged course, causing the development of complications [8].

The severity of reactive synovitis was assessed by the presence of clinical signs (pain syndrome, positive symptom of "floating patella") and sonography. The effectiveness of sonography lies in the ability to visualize the structures of the knee joint in the dynamics [9].

To determine the intensity of the reactive synovial fluid accumulation in the upper torsions of the knee joint the following scale was used: 0 - no fluid in the joint cavity, I - maximum fluid layer thickness < 2 mm, II - fluid layer thickness $2 - 4$ mm, III - fluid layer thickness > 4 mm [10].



Fig. 1. Appearance of «GIOCO CRYO - 2» system

Table I. Dynamics of pain syndrome and the height of the knee joint reactive exudate layer in the postoperative period

Groups	Pain syndrome (points)		
	Examination day		
	Day 1	Day 3	Day 10
EG (n=32)	5,81±0,12	4,98±0,23	1,03±0,25
CG (n=31)	7,49±0,18	6,11±0,25	2,70±0,21
P	p<0,001	p<0,001	p<0,001
	Height of the reactive exudate layer (mm)		
EG (n=32)	2,14±0,04	1,84±0,04	1,32±0,03
CG (n=31)	2,76±0,04	2,33±0,12	1,64±0,03
P	p<0,001	p<0,001	p<0,01

Table II. Dynamics of the amplitude of knee joint movements and myotonometry of the quadriceps femoris of patients in the postoperative period

Groups	Amplitude of movements (degrees)					
	Day 1		Day 3		Day 10	
	Bending	Extension	Bending	Extension	Bending	Extension
EG (n=32)	30,3±3,0	171,9±2,6	90,0±2,5	175,1±2,0	126,8±2,6	178,2±2,0
CG (n=31)	27,52±2,34	168,30±2,66	67,74±2,38	168,19±2,20	105,42±3,40	170,03±2,43
P	p<0,001		p<0,001		p<0,001	
Groups	Myotonometry (myotones)					
	Day 1		Day 3		Day 10	
	Resting tone	Tension tone	Resting tone	Tension tone	Resting tone	Tension tone
EG (n=32)	62,69±2,36	64,56±1,64	46,16±1,63	54,38±2,08	58,47±2,59	81,97±2,13
CG (n=31)	63,70±1,56	64,90±1,42	43,60±1,89	53,50±1,65	56,70±2,07	69,70±2,82
P	p>0,05		p<0,01	p>0,05	p<0,01	p<0,001

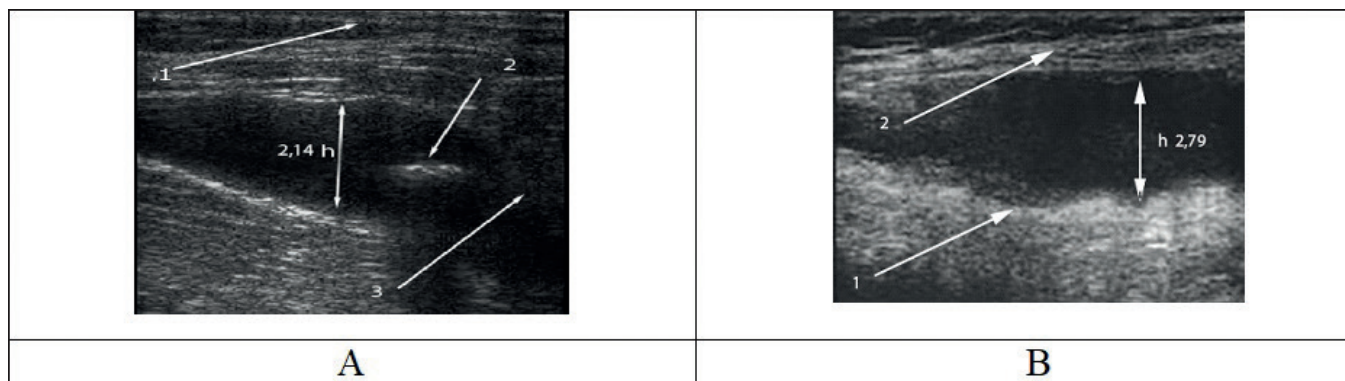


Fig. 2. The height of the layer of reactive exudate on the first day after the intervention in the joint cavity of the patients.
 A. Experimental group. h – the height of the layer of reactive exudate in the upper torsion of the knee joint; 1 - the tendon of the quadriceps femoris; 2 - fibrin clot in the upper torsion of the knee joint; 3 - kneecap.
 B. Control group. h – the height of the layer of reactive exudate in the upper torsion of the knee joint; 1 – the cortical layer of the femur; 2 - the tendon of the quadriceps femoris.

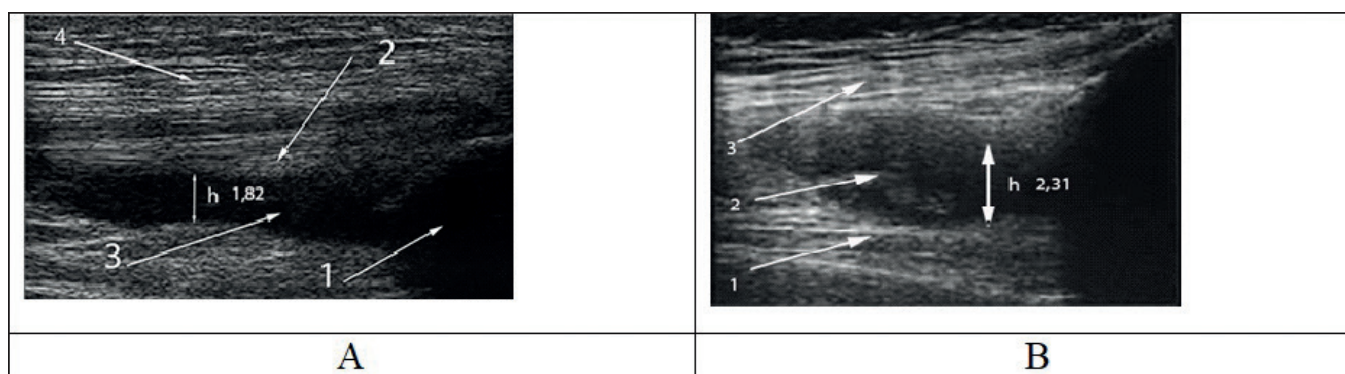


Fig. 3. The height of the layer of reactive exudate on the third day after the intervention in the joint cavity of the patients.
 A. Experimental group. h – the height of the layer of reactive exudate in the upper torsion of the knee joint; 1 - kneecap; 2 - synovial membrane of the knee joint; 3 - reactive fluid in the upper torsion of the knee joint; 4 - tendons of the quadriceps femoris.
 B. Control group. h – the height of the layer of reactive exudate in the upper torsion of the knee joint; 1 - the cortical layer of the femur; 2 - synovial fluid with fibrine in the upper torsion of the knee joint; 3 - tendons of the quadriceps femoris.

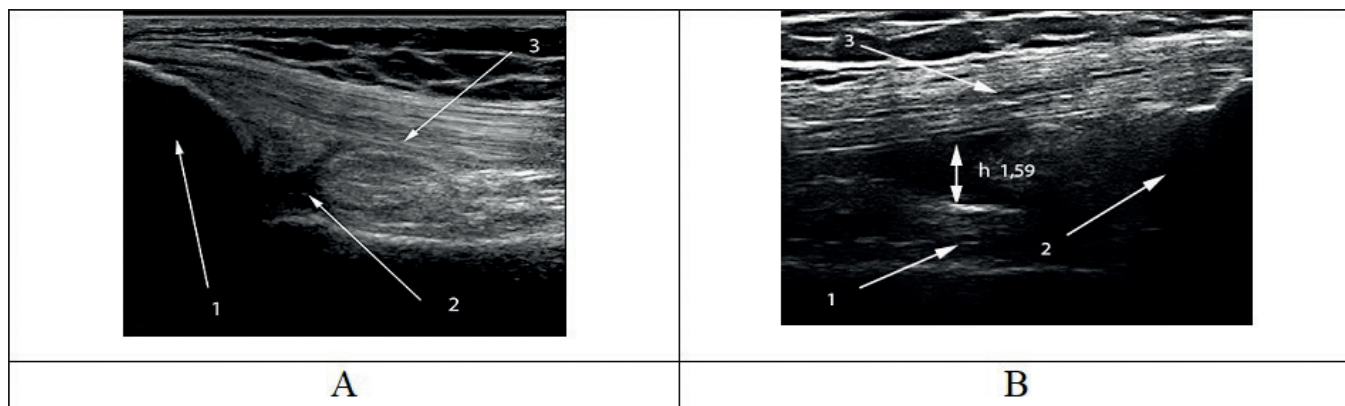


Fig. 4. The height of the layer of reactive exudate on the tenth day after the intervention in the joint cavity of the patients.
 A. Experimental group. 1 - kneecap; 2 - upper torsion of the knee joint; 3 - tendons of the quadriceps femoris.
 B. Control group. h - the height of the layer of reactive exudate in the upper torsion of the knee joint; 1 - cortical layer of the femur; 2 - kneecap; 3 - tendons of the quadriceps femoris.

On the first day after cryotherapy, the average height of the reactive exudate layer in the knee joint of patients in the experimental group was $2,14 \pm 0,031$ mm, in the control group it was significantly higher – $2,76 \pm 0,040$ mm ($p < 0,001$) (table I, fig 2).

On the third day of cryotherapy, the amount of exudate gradually decreased in both groups. However, in the experimental group, the height of the exudate layer was $1,84 \pm 0,038$ mm, and in

the control group, it was higher by $2,33 \pm 0,123$ mm ($p < 0,001$) (Fig. 3).

Lowering the height of the synovial fluid layer in the knee joint under the influence of cryotherapy with adjustable pulse compression made it possible to reduce the number of punctures. Thus, on the third day, only 15,6% of patients in the experimental group had a joint puncture, while in the control group there were 29% of such patients.

On the tenth day, the height of the synovial fluid layer in patients of the experimental group decreased to $1,32 \pm 0,028$ mm according to the results of sonography, and in the control group - only to $1,64 \pm 0,033$ mm ($p < 0,01$) (Fig. 4).

Another important indicator of the effectiveness of the early period of rehabilitation after surgical intervention on the knee joint is the restoration of the range of motion. The results of the assessment of these indicators after cryotherapy are presented in Table II. Thus, on the first day after cryotherapy, the bending in the operated knee joint in the experimental group was $30,3 \pm 3,0^\circ$, and in the control group - $27,52 \pm 2,34^\circ$ ($p < 0,001$). The extension indicators were as follows: experimental group $171,9 \pm 2,6^\circ$, control group $168,30 \pm 2,66^\circ$ ($p < 0,001$).

On the third day of observation, the bending in the knee joint in the experimental group increased to $90,0 \pm 2,5^\circ$ (an increase of 99,3%), and in the control group - only to $67,74 \pm 2,38^\circ$ (an increase of 84,50%) ($p < 0,001$). The results of knee joint extension in EG were $175,1 \pm 2,0^\circ$ (an increase of 1,87%) and in CG - $168,0 \pm 2,20^\circ$ (decrease by 0,06%) ($p < 0,001$).

On the tenth day, bending in the knee joint in the experimental group increased to $126,8 \pm 2,6^\circ$ (an increase of 122,90%), and in the control group - only to $105,42 \pm 3,4^\circ$ (an increase of 117,20%) ($p < 0,001$). The joint extension data were, respectively, $178,2 \pm 2,0^\circ$ (an increase of 3,62%) and $170,03 \pm 2,43^\circ$ (an increase of 1,02%) ($p < 0,001$).

The muscle tone is definitely reflex in nature and is an important indicator that reflects the dynamics of functional recovery of patients after trauma and surgery. Deficiency of activity and atrophy contribute to the weakness of the quadriceps femoris as the main stabilizer of the knee joint [11].

One of the methods of objective assessment of the functional state of the muscle is myotonometry. To determine muscle tone, we used «MYOTONOMETER PAT.D. SZIRMAI Gy. sz 64451» (Hungary).

On the first day after surgery in the patients of the studied groups, the resting tone of the quadriceps femoris was increased as a result of pain in the knee joint and, accordingly, was $62,69 \pm 2,36$ myotones in the experimental group, and in the control group - $63,70 \pm 1,56$ myotones ($p > 0,05$) (Table II). The tension tone of the

quadriceps femoris did not differ significantly in both groups ($p > 0,05$).

Studies of the muscle tone of the quadriceps femoris on the third day showed its decrease due to reduced motor activity of patients in both groups. Thus, the resting tone in the experimental group was $46,16 \pm 1,63$ myotones (decreased by 30,4%), and the tension tone - $54,38 \pm 2,08$ myotones (decreased by 17,4%). In the control group, these indicators were as follows: resting tone $43,60 \pm 1,89$ myotones (decrease by 37,4%), tension tone $53,50 \pm 1,65$ myotones (decrease by 19,17%).

On the tenth day after surgery, a gradual increase in muscle tone was noted in both groups, but the amount of increase was different. So, in EG, at maximum tension, the tone of the quadriceps femoris was $81,97 \pm 2,13$ myotones (an increase of 23,8%), at rest, it was $58,47 \pm 2,59$ myotones (an increase of 7,00%), which indicates an improvement in the condition of the neuromuscular apparatus in patients of this group. In the control group, the indicators were $69,70 \pm 2,82$ myotones (an increase of 7,09%) and $56,70 \pm 2,07$ myotones (an increase of 11,63%), respectively. The significance of the difference between the indicators of the groups is at the $p < 0,01-0,001$ level.

DISCUSSION

Cryotherapy is one of the common means of both single and combined treatment of patients after injuries and operations. The use of cold increases vasoconstriction, which reduces tissue metabolism. Slowing down blood flow helps reduce the inflammatory response and swelling [12].

Local cooling slows down the transmission of the pain signal, thus reducing it [13].

The results of our research indicate the effectiveness of both methodologies of cryotherapy in patients after partial meniscectomy. However, the analysis of the dynamics of the indicators recovery such as the intensity of the pain syndrome, the severity of reactive synovitis, the increase in the amplitude of movements in the joint and the tone of the quadriceps femoris shows that in the patients of the experimental group who used cryotherapy with pulse compression, the recovery was more effective and significant ($p < 0,05-0,001$), compared to patients of the control group who used ice bags.

So, already on the first day of rehabilitation after surgery, the patients of the experimental group felt moderate pain, and of the control one - experienced severe pain. The dynamics of decreasing pain intensity indicators in EG was observed until the tenth day of the study in comparison with CG.

Lowering the height of the layer of synovial fluid in the knee joint under the influence of cryotherapy with

adjustable pulse compression made it possible to reduce the number of punctures. So, on the third day, only 15,6% of patients in the experimental group underwent a joint puncture, and in the control group, there were 29% of such patients, which is also a positive indicator of the cryotherapy with pulse compression effectiveness.

Regarding the restoration of the movements amplitude of the operated knee joint, according to our data, a progressive increase in the bending function was established with a growth of 99,3% in patients of the experimental group already on the third day in comparison with the control group (84,5%). There is a statistically significant difference between CG and EG ($p < 0,001$). These data are consistent with the results obtained by other authors [14,15].

It is necessary to note studies that demonstrate the average effectiveness of cryotherapy in improving the activation of the knee joint after surgical interventions [16].

However, despite a number of controversial issues and possible complications during cold treatment, cryotherapy devices with pulse compression demonstrate good results after arthroscopic partial meniscectomy in comparison with other procedures due to a significant reduction in pain, swelling, analgesic consumption, increased range of motion and muscle tone.

CONCLUSIONS

The analysis of the research results of the various methods of cryotherapy impact made it possible to establish that:

Both methods have positive dynamics of the functional state of the knee joint restoration after partial meniscectomy. However, patients of the experimental group who used cryotherapy with adjustable pulse compression in the postoperative period had more positive and significant dynamics (on the first, third, and tenth day) than patients of the control group ($p < 0,05-0,001$) who used bags with ice.

The pain syndrome in patients of the experimental group already on the first day of rehabilitation decreased to moderate ($5,81 \pm 0,12$ points), and in the control group, it was characterized as severe ($7,49 \pm 0,18$ points) ($p < 0,001$).

The reduction of clinical manifestations and sonographic indicators of reactive synovitis made it possible to reduce the number of knee joint punctures. It was performed only in 15,6% of EG patients, while in CG there were 29% of such patients, which is also a positive indicator of the cryotherapy with pulse compression effectiveness.

In the experimental group, the restoration of the range of motion in the operated knee joint and the improvement of the muscle tone of the quadriceps femoris occurred faster and more effectively during the entire study period than in the control group.

So, cryotherapy with adjustable pulse compression has shown a positive effect on the functional state of the knee joint in the early period of patients' rehabilitation, after partial meniscectomy and is more effective than cryotherapy using ice bags; that is why it can be recommended for use in clinical practice.

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